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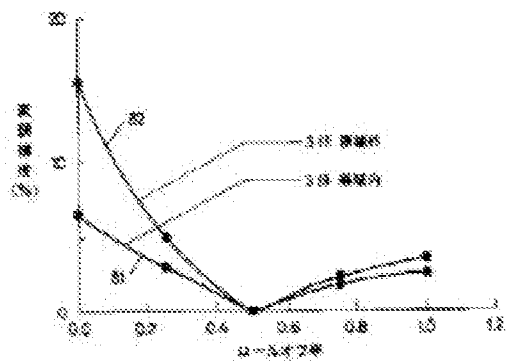
(54) INTERMEDIATE FREQUENCY FILTER

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a an intermediate frequency filter whose design and manufacture are facilitated and which can be miniaturized.
SOLUTION: Frequency width containing the 3dB attenuation point of an output signal against an input signal is set to be 3dB band width through which the input signal band-passes. A characteristic exhibiting transmission loss larger than a route off filter in a pass band and a characteristic exhibiting the transmission loss smaller than the route roll off filter in an attenuation band are given as transition band characteristics between a pass band corresponding to the inside of the 3dB band width and the attenuation band corresponding to the outside of the 3dB band with, based on the route roll off filter whose roll off rate is 0.5.



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CLAIMS

[Claim(s)]
[Claim 1]A frequency span which chooses and outputs a specific frequency component of an input signal, and includes even a point over said input signal of the output signal decreasing [3 dB], Based on a route roll-off filter which said input signal determined as the 3-dB bandwidth which carries out a band pass, and made the rate 0.5 of a roll-off, as the transient region characteristic between a pass band [/ in said 3 dB bandwidth], and a decay area corresponding to outside of said 3-dB bandwidth, said pass band -- said route roll-off filter -- size -- the characteristic which presents path loss, and said decay area -- said route roll-off filter -- smallness -- an intermediate frequency filter constituted so that it might have the characteristic which presents path loss.
[Claim 2]A frequency span which chooses and outputs a specific frequency component of an input signal, and includes even a point over said input signal of the output signal decreasing [3 dB], It is an intermediate frequency filter with which the characteristic of a route roll-off filter determined as the 3-dB bandwidth in which said input signal carries out a band pass is obtained, An intermediate frequency filter which the 3-dB bandwidth in the intermediate frequency filter concerned is **8.5 kHz thru/or **13.0 kHz, and was constituted so that a rate of a roll-off might be set to 0.9 thru/or 1.0.
[Claim 3]A frequency span which chooses and outputs a specific frequency component of an input signal, and includes even a point over said input signal of the output signal decreasing [3 dB], It is an intermediate frequency filter with which the characteristic of a route roll-off filter determined as the 3-dB bandwidth in which said input signal carries out a band pass is obtained, An intermediate frequency filter which the 3-dB bandwidth in the intermediate frequency filter concerned is **9.0 kHz thru/or **13.0 kHz, and was constituted so that a rate of a roll-off might be set to 0.6 thru/or 1.0.
[Claim 4]A frequency span which chooses and outputs a specific frequency component of an input signal, and includes even a point over said input signal of the output signal decreasing [3 dB], It is an intermediate frequency filter with which the characteristic of a route roll-off filter determined as the 3-dB bandwidth in which said input signal carries out a band pass is obtained, An intermediate frequency filter which the 3-dB bandwidth in the intermediate frequency filter concerned is **9.5 kHz thru/or **13.0 kHz, and was constituted so that a rate of a roll-off might be set to 0.5 thru/or 1.0.
[Claim 5]A frequency span which chooses and outputs a specific frequency component of an input signal, and includes even a point over said input signal of the output signal decreasing [3 dB], An intermediate frequency filter with which it is an intermediate frequency filter with

which the characteristic of a route roll-off filter determined as the 3-dB bandwidth in which said input signal carries out a band pass is obtained, and group delay frequency characteristics in the 3-dB bandwidth in the intermediate frequency filter concerned have two or more ripples.
[Claim 6]A frequency span which chooses and outputs a specific frequency component of an input signal, and includes even a point over said input signal of the output signal decreasing [3 dB], It is an intermediate frequency filter with which the characteristic of a route roll-off filter determined as the 3-dB bandwidth in which said input signal carries out a band pass is obtained, An intermediate frequency filter with which group delay frequency characteristics in the 3-dB bandwidth in the intermediate frequency filter concerned have two or more ripples, and it was made for a peak of the ripple to be located in frequency other than center frequency of the intermediate frequency filter concerned.
[Claim 7]The intermediate frequency filter according to claim 6 with which only frequency equivalent to 25% of the 3-dB bandwidth in the intermediate frequency filter concerned and 50% located a peak of a ripple of group delay frequency characteristics in the low-pass side of the 3-dB bandwidth.
[Claim 8]The intermediate frequency filter according to claim 6 with which only frequency equivalent to 25% of the 3-dB bandwidth in the intermediate frequency filter concerned and 50% located a peak of a ripple of group delay frequency characteristics in the high region side of the 3-dB bandwidth.
[Claim 9]alienation with a peak of a ripple of group delay frequency characteristics, and center frequency of the intermediate frequency filter concerned -- the intermediate frequency filter according to claim 6 which made a frequency span a frequency span equivalent to 25% of the 3-dB bandwidth in the intermediate frequency filter concerned, and 50%.
[Claim 10]The intermediate frequency filter according to any one of claims 1 to 9 constituted using a piezoelectric ceramic element.
[Claim 11]The intermediate frequency filter according to any one of claims 1 to 9 constituted using a surface acoustic element.
[Claim 12]The intermediate frequency filter according to any one of claims 1 to 9 constituted using an integrated switched capacitor.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention is used for a wireless-radios machine, and relates to the intermediate frequency filter which passes only the intermediate frequency signal.
[0002]
[Description of the Prior Art]The main problems in digital signal transmission art are that a digital error increases by the intersymbol interference which originates in distortion of the pulse shape by which it is generated when a pulse signal passes through a transmission line, and the pulse signal receives.
[0003]Usually, the frequency spectra of a rectangular pulse have an infinite frequency component theoretically. Therefore, if it is going to receive correctly the rectangular pulse waveform transmitted through the transmission line, It is required for a transmission line to be able to transmit an infinite frequency component ideally, therefore a wide band is extremely required of the frequency characteristic over the transmission signal of a transmission line, and in

addition, this will receive to an unnecessarily excessive noise component undesirably, seeing from the utilization efficiency of transmission frequency bandwidth.
[0004]If a line band is narrowed in order to decrease this noise component, a received-pulses waveform will spread in a time base direction, and it will be affected at the discernment time between the contiguity pulses of order. Therefore, intersymbol interference is small, there are few noises, namely, to equalize in the pulse shape with which a digital error rate serves as the minimum is desired.
[0005]The most fundamental band limit is use of the filter which has the ideal low-pass filter characteristic. When an impulse is impressed to this filter, a response serves as the response waveform 151 of well-known as shown in drawing 15.
[0006]In this response waveform 151, a zero appears in every T_0 (=1/2f_0) except for the peak of the center in t= 0. If interval T_0 to t=0-T_0 in this case is called Nyquist interval 152 and an impulse train is transmitted with this Nyquist interval 152, intersymbol interference will be thoroughly avoided to the momentary detection performed in the center of received pulses.
[0007]Since a fundamental wave component is intercepted, the train of impulses of an interval smaller than this Nyquist interval 152 is not transmitted by usual. That is, the bit rate corresponding to Nyquist interval 152 has given the transmission limit in the zone.
[0008]Extraordinary difficulty is followed on realizing the above ideal low-pass filter characteristics in practice. Then, in order to search for the conditions of the filter in an actual transmission line, the 1st standard of nyquist is used.
[0009]As it is indicated in drawing 16 (a) as the 1st standard of nyquist, about interception angular-frequency omega$_0$, Also as the filter characteristics 163 as applied the filter characteristics 162 of the ** symmetrical filter which has the characteristic symmetrical with ** to the filter characteristics 161 of an ideal filter, compounded them and shown in drawing 16 (b), As shown in drawing 16 (d), I hear that the intersection to the horizontal axis (omega$_0$t) of the impulse response waveform 165 does not change, and there is.
[0010]The filter characteristics shown in drawing 16 (b) and drawing 16 (c) have the characteristic that realization is possible and no intersymbol interference is to the impulse transmission of repeat frequency [of 2f] $_0$. The frequency characteristic symmetrical with ** which can be added to the filter characteristics 161 of an ideal filter exists infinitely, and the synthesizing filter characteristic which added in this way and was made also exists infinitely. The filter characteristics generally widely used among this synthesizing filter characteristic are the filter characteristics 163 shown in drawing 16 (b).
It is called roll-off spectrum and expressed with (the formula 1).

[0011]
[Equation 1]

$$H(\omega)=\begin{cases}1 \cdots\cdots & 0 \leqq \omega \leqq \omega_0(1-\alpha)\\ \frac{1}{2}\left[1-\sin\left\{\frac{\pi}{2\alpha\omega_0}(\omega-\omega_0)\right\}\right] \cdots\cdots & \omega_0(1-\alpha) \leqq \omega \leqq \omega_0(1+\alpha)\\ 0 \cdots\cdots & \omega \geqq \omega_0(1+\alpha)\end{cases} \quad \cdots (式1)$$

[0012]By calling alpha the rate of a roll-off here by the coefficient which shows the degree of the

inclination of a band limit, and changing the value of this rate alpha of a roll-off in (0<=alpha<=1), As shown in drawing 16 (c), it is changed from the filter characteristics [in / for filter characteristics / alpha= 0] 164a before the filter characteristics 164b in alpha= 1. omega$_0$ is expressed like omega$_0$=piT$_0$ using Nyquist interval T$_0$.
[0013]Usually, it becomes the optimal transmission system characteristic for the combination of the route roll-off filter characteristic which distributed the characteristic of being expressed with the above-mentioned (formula 1) to division into equal parts at the transmitting side and the receiver of the transmission system to make a digital error rate the minimum.
[0014]In order to observe visually the received-pulses waveform containing intersymbol interference and a noise, the eye diagram (eye pattern) typically drawn on drawing 17 is convenient. An eye diagram is the waveform which restored to the digital signal sequence modulated by the random pulse by the receiver, took the synchronization by the clock pulse and described this demodulation waveform on the oscilloscope.
[0015]The opening part 171 of the waveform pattern which carried out the form of the eye near the identification point of the eye diagram shown in drawing 17 can be called an eye, and it can ask for the degree of margin of numerals discernment from this numerical aperture. Supposing there is deltaV in the direction of an oscillation axis (lengthwise direction) and the numerical aperture of an eye has degradation of deltaT to an ideal eye in a time base direction (transverse direction), The eye numerical aperture of v_a/V_p and a time base direction is expressed with t_a/T_p, and the eye numerical aperture of the direction of an oscillation axis can evaluate the quality of the transmission system characteristic by these eye numerical apertures.
[0016]However, since it complains of the evaluation by this eye numerical aperture to human being's feeling intuitively, as qualitative observation, it is convenient, but there are some which lack in quantitative evaluation. On the other hand, as a quantitive rate scale of a digital signal transmission system, there is a vector amplitude error showing an error with the modulated wave type of an ideal. This is a value of the vector amplitude error 182 which expressed the gap from the ideal signal 181 based on the coordinates R of the amplitude/phase of ideal pi / 4 shift QPSK signal, and the coordinates S of the amplitude/phase of pi / 4 shift QPSK signal actually measured, as shown in drawing 18.
[0017]Generally, (absolute value of vector amplitude error 182)/(absolute value of the amplitude of the ideal signal 181) is called modulation accuracy, and it is considered as the rate scale in a digital signal transmission system. In the RCR (Research & Development Center of Radio System) standard, modulation accuracy is determined as less than 12.5% in the sending signal.
[0018]As mentioned above, in a digital transmission system, As most typical filter that realization of the transmission line which loses intersymbol interference to an impulse signal, and where little response of a digital error is obtained becomes important, and can realize such an impulse response, A roll-off filter is mentioned and the digital error rate resulting from intersymbol interference can be reduced also in a digital radio transmission system by using this roll-off filter as an intermediate frequency filter of the communication equipment in a digital radio transmission system.
[0019]Of course, a roll-off filter suitable for digital signal transmission described above can be easily constituted using discrete part, such as an inductor and a capacitor, and is used from the former. However, there is a limit in the miniaturization, and the LC filter constituted using such an inductor (L), a capacitor (C), etc. cannot fully satisfy the request of the time of microminiaturization of the present communication equipment, and has already become the past thing.

[0020]By then, development of the presentation called the three component systems PZT since piezoelectricity was checked in the ceramic element made from barium titanate ($BaTiO_3$). The piezoelectric ceramic material which a dielectric constant, piezoelectricity, a mechanical quality factor, temperature characteristics, etc. can choose now freely, . Compared with other piezoelectric material, the wide range characteristic is obtained by changing the presentation whose piezoelectricity is size and whose dielectric constant is size. Since it has many features which are the extremely stable low cost with mass production nature which can form shape freely, and are referred to as suitable for the miniaturization etc., it came to be widely used as a material of a resonator.
[0021]Therefore, can use this piezoelectric ceramic material as a raw material of the intermediate frequency filter of the 450-kHz belt used for digital mobile communications equipment, and as an intermediate frequency filter in digital mobile communications equipment from the former, Many ceramics filters constituted using the above-mentioned piezoelectric ceramic material are used.
[0022]
[Problem(s) to be Solved by the Invention]However, although it is widely used from the necessity for the miniaturization and uses as the intermediate frequency filter in the mobile communications equipment in a digital radio transmission system now in the conventional intermediate frequency filter constituted by the above ceramics filters, This ceramics filter assumes a gap of the frequency by temperature characteristics etc., It is most which designed a **10.5-kHz 3-dB pass band width, provided means, such as carrying out external [of the resistor] to a resonator in order to decrease a group delay deviation, and has acquired the modulation accuracy of required **, In the case where this kind of filter is used for a digital transmission system, although the actual condition is that it is [that there is nothing] near in practical information useful to that design and manufacture and the miniaturization was completed, the design had the problem that it was difficult and manufacture was not easy.
[0023]In general radio frequency signal transmission systems, such as a digital signal transmission system using a radio frequency signal, In [as for the above ceramics filters, it is common to be used only for a receiver as an intermediate frequency filter, therefore] a digital radio transmission system, Realizing route roll-off characteristics by the above-mentioned problem in the receiver for which the intermediate frequency filter which comprised above ceramics filters is used also had the problem of being very difficult.
[0024]When this invention solves the above-mentioned problem and it uses it as an intermediate frequency filter of the communication equipment in a digital radio transmission system, The digital error rate which has outstanding filter characteristics and originates in intersymbol interference can be reduced, and the intermediate frequency filter which can make design and manufacture easy further, and can be miniaturized is provided.
[0025]
[Means for Solving the Problem]In order to solve an aforementioned problem, the intermediate frequency filter of this invention according to claim 1, A frequency span which chooses and outputs a specific frequency component of an input signal, and includes even a point over said input signal of the output signal decreasing [3 dB], Based on a route roll-off filter which said input signal determined as the 3-dB bandwidth which carries out a band pass, and made the rate 0.5 of a roll-off, as the transient region characteristic between a pass band [/ in said 3 dB bandwidth], and a decay area corresponding to outside of said 3-dB bandwidth, said pass band -- said route roll-off filter -- size -- the characteristic which presents path loss, and said decay area -

- said route roll-off filter -- smallness -- it constitutes so that it may have the characteristic which presents path loss.
[0026]According to this composition, when it is used as an intermediate frequency filter of communication equipment in a digital radio transmission system, it acts so that a digital error rate resulting from intersymbol interference may be reduced.
[0027]
[Embodiment of the Invention]Hereafter, the intermediate frequency filter in which an embodiment of the invention is shown is explained, referring to Drawings.
[0028]As conventional technology explained, when using a ceramics filter made from a piezoelectric ceramic material as an intermediate frequency filter of the communication equipment in a digital radio transmission system, From the Reason the design and manufacture for reducing the digital error rate which has outstanding filter characteristics and originates in intersymbol interference are not easy. In the ceramics filter of the 450-kHz belt used for digital mobile communications equipment, the actual condition is that realization of route roll-off characteristics without intersymbol interference is very difficult.
[0029]Therefore, by investigating the influence which it has on the transmission system characteristic when filter characteristics separate from route roll-off characteristics here, The result of having examined the desirable characteristic of the ceramics filter is explained to the case where a ceramics filter is used as above intermediate frequency filters.
[0030]Evaluation of filter characteristics was performed by searching for the modulation accuracy showing the gap from an ideal signal (state without intersymbol interference), i.e., (absolute value of vector amplitude error)/, (absolute value of ideal signal amplitude) in a simulation.
[0031]First, when modulation accuracy estimates filter characteristics, the outline procedures of the modulation accuracy simulation used for the evaluation are enumerated below, and are explained briefly. The procedure of this modulation accuracy simulation creates random data using 15 steps of (1) M sequence.
[0032](2) Change binary code into a gray code.
(3) Map a gray code in pi / 4 shift QPSK.
(4) Calculate the impulse response of a route roll-off filter.
[0033](5) Create the repetition waveform for FFT.
(6) Perform a convolution integral.
(7) Pass a linear amplifier and amplify.
[0034](8) Ask for the maximum, the minimum, and average power.
(9) Ask for a frequency domain by FFT.
(10) Create the data for a plot in a frequency domain.
[0035](11) Pass a receiving filter in a frequency domain.
(12) Search for a segment of time by FFT.
(13) Plot data on a phase plane.
[0036](14) Ask for an amplitude error and a phase error.
(15) Calculate modulation accuracy.
(16) Change inclination of the phase of a filter.
** -- it becomes like. Here, integration of (6) is performed by passing a route roll-off filter, the characteristic of the receiving filter of (11) is incorporated from a ceramics filter design program or data measuring, and the filter characteristics are given with amplitude and a phase. In pi / 4 shift QPSK modulation, in order to apply abnormal conditions by relative displacement of a

phase, as for inclination of the phase of a filter, whether only in which, not a problem but the phase has shifted from the straight line poses a problem. For this reason, a phase is incorporated with the straight line used as a standard, and is given with the difference of data. The slope of a line used as a standard shall repeat (11) - (16), and shall make modulation accuracy the minimum.

[0037]The combination of the various filter characteristics which show drawing 1 - drawing 5 the above-mentioned simulation was followed. By the case where drawing 2 is between transmission and reception, and it has roll-off characteristics by the case where drawing 1 is between transmission and reception, and it has route roll-off characteristics. By the case where a receiver filter has an A-weighting function with route roll-off characteristics, a transmitting side filter drawing 3. In the case where, as for drawing 4, a receiver filter has B weighting with route roll-off characteristics in a transmitting side filter, drawing 5 is a case where a transmitting side filter has route roll-off characteristics, and a receiver filter has C weighting. The actual measurement of the modulation accuracy about these filter characteristics and the result of the simulation were shown as compared with (Table 1).

[0038]

[Table 1]

	送受信間ルートロールオフ	送受信間ロールオフ特性	送信側ルートロールオフフィルタ		
			受信側A特性	受信側B特性	受信側C特性
実　測	13.8%	0.7%	7.0%	7.5%	12.6%
シミュレーション	14.2%	0.0%	6.9%	8.0%	11.8%

（表1）

[0039]this (Table 1) -- from -- it is admitted that the actual measurement and simulation value of modulation accuracy are well in agreement so that clearly. Therefore, suppose that evaluation of the filter characteristics in this embodiment is performed with the simulation of modulation accuracy.

[0040]In order to miniaturize a 450-kHz belt ceramics filter, it is effective to use the rectangular plate vibrator using the length vibration mode of a piezoelectric transducer as a filter element. However, since the interval of resonance frequency-antiresonant frequency is small compared with spread vibration when using length vibration mode, the problem that the design of the filter of a broadband is difficult occurs. Then, the influence which change of bandwidth has on modulation accuracy was considered.

[0041]On the occasion of this examination, a transmission system is used with 3dB bandwidth =**10.5kHz, The 3-dB bandwidth of the route roll-off filter which gives the characteristic as an intermediate frequency filter of a receiving system, and the rate alpha of a roll-off were changed using the intermediate frequency filter which has the characteristic of the route roll-off filter made into the rate alpha= 0.5 of a roll-off, and the modulation accuracy was evaluated. It corresponds to the ceramics filter which the route roll-off filter of a receiving system examines. Here, the characteristic of each filter shall have the linear phase characteristic. The examining result by the above conditions is shown in ((Table 2 and 3)).

[0042]

[Table 2]

ロールオフ率 α	帯域幅 ±8.5kHz	帯域幅 ±9.0kHz	帯域幅 ±9.5kHz	帯域幅 ±10.0kHz	帯域幅 ±10.5kHz
0.5	18.1%	12.2%	7.2%	3.2%	0.0%
0.6	14.9%	9.9%	5.9%	2.7%	0.3%
0.7	12.4%	8.3%	5.0%	2.3%	0.6%
0.8	10.5%	7.1%	4.4%	2.2%	1.4%
0.9	9.1%	6.2%	3.9%	2.3%	1.9%
1.0	7.8%	5.4%	3.6%	2.5%	2.4%

（表2）

[0043]
[Table 3]

ロールオフ率 α	帯域幅 ±11.0kHz	帯域幅 ±11.5kHz	帯域幅 ±12.0kHz	帯域幅 ±12.5kHz	帯域幅 ±13.0kHz
0.5	2.6%	4.7%	6.4%	7.8%	9.0%
0.6	2.2%	4.0%	5.5%	6.8%	7.9%
0.7	2.1%	3.6%	4.9%	6.0%	7.0%
0.8	2.2%	3.4%	4.6%	5.6%	6.4%
0.9	2.6%	3.5%	4.5%	5.4%	6.1%
1.0	3.0%	3.8%	4.6%	5.4%	6.0%

（表3）

[0044]In (Table 2) and the (Table 3), when 3-dB bandwidth is **10.5 kHz, modulation accuracy serves as best, Other than this, even when jam bandwidth of 3 dB is larger than it, and even when small, it is shown that modulation accuracy deteriorates, and it is also shown that these things can say similarly about all the rates of a roll-off.
[0045]Since the direction which makes 3-dB bandwidth large is smaller than the direction to narrow, the degree of degradation is understood that the deterioration degree by dispersion in frequency is small advantageous when 3-dB bandwidth is designed width. Speaking of the rate of a roll-off, the optimum value of the rate of a roll-off which makes modulation accuracy best exists with 3-dB bandwidth. When narrowing 3-dB bandwidth, there is a tendency for the degradation rate of modulation accuracy to decrease, by enlarging the rate of a roll-off.
[0046]Thus, when 3-dB bandwidth is narrow, it is possible to reduce degradation of modulation accuracy by enlarging the rate of a roll-off, but it is guessed that the frequency drift by temperature characteristics has an adverse effect on modulation accuracy compared with the case where 3-dB bandwidth is wide.
[0047]Generally, it is thought that the energy distribution of a transmission signal is concentrated in the 3-dB bandwidth of a filter. Therefore, when the filter characteristics in 3-dB bandwidth change, naturally change of modulation accuracy is expected.
[0048]Drawing 6 and drawing 7 are the characteristic figures of the low-pass filter which is going to evaluate change of modulation accuracy. Drawing 6 and drawing 7 are based on the

same low-pass filter, and are a characteristic figure of the various low-pass filters to which the internal and external rate of a roll-off of the 3-dB bandwidth was changed.
[0049]These filter characteristics are based on the route roll-off filter of 3dB bandwidth =10.5kHz and the rate alpha= 0.5 of a roll-off. Drawing 6 shows filter characteristics when drawing 7 changes the rate alpha of a roll-off into 0, 0.25, 0.75, and 1.0 with the frequency band of a high region rather than 10.5 kHz, when the rate alpha of a roll-off is changed into 0, 0.25, 0.75, and 1.0 with a low-pass frequency band rather than 10.5 kHz. However, it assumes that a phase is constant and group delay frequency characteristics are not taken into consideration. The dashed line 61 in drawing 6 and drawing 7 shows the filter characteristics of the route roll-off filter of the rate alpha= 0.5 of a roll-off in a transmission system, respectively.
[0050]The evaluation result of the modulation index in the transmission system of the filter characteristics shown in drawing 6 and drawing 7 is shown in drawing 8. Drawing 8 the rate of a roll-off in the modulation accuracy characteristic 81 at the time of making it change within 3-dB bandwidth. In the modulation accuracy characteristic 82 at the time of degradation of modulation accuracy becoming less than the case where the rate alpha of a roll-off becomes smaller [it / to become larger than 0.5], a little, and changing the rate of a roll-off out of 3-dB bandwidth. It means that degradation of modulation accuracy becomes less than the case where the rate alpha of a roll-off becomes smaller [it / to become larger than 0.5], remarkably.
[0051]When in other words it is a filter whose 3-dB bandwidth is **10.5 kHz, The transmission quantity in 3-dB bandwidth to the transmission quantity of the route roll-off characteristics of the rate 0.5 of a roll-off the direction of few filter characteristics, Compared with many filter characteristics, degradation of modulation accuracy is small, and degradation of modulation accuracy has the small transmission quantity besides 3-dB bandwidth compared with filter characteristics with few many filter characteristics to the transmission quantity of the route roll-off characteristics of the rate 0.5 of a roll-off. The degree of degradation is remarkable when transmission quantity out of band 3 dB becomes less than the transmission quantity of the route roll-off characteristics of the rate 0.5 of a roll-off.
[0052]Since the filter characteristics with the small rate alpha of a roll-off are the things of a very steep operating characteristic, realization is difficult, and the actual rate of a roll-off becomes large easilier than 0.5. Therefore, the characteristic in 3-dB bandwidth becomes important from a viewpoint of raising modulation accuracy.
[0053]So far, although the examining result about the amplitude characteristic of a filter has been explained, the analysis result about group delay frequency characteristics is explained henceforth. The group delay frequency characteristics of a ceramics filter are absolutely governed by group delay and the group delay ripple deviation. By any means, group delay specifies the timing of the transmission and reception in Transmission Systems Division, and does not affect modulation accuracy. On the other hand, a group delay ripple deviation causes waveform distortion at the time of a signal passing a filter, and has direct influence on modulation accuracy.
[0054]The number of group delay ripples in the 3-dB bandwidth of a filter (the number of the mountains of the group delay on a frequency axis) changes a little with designing methods. In regulation of the present group delay frequency characteristics, although the ripple deviation is defined, it is not defined to the number of ripples. Here, the relation between a group delay ripple deviation and modulation accuracy is considered, and when a ripple deviation is still more nearly equal, and the numbers of ripples differ, the influence modulation accuracy is influenced is considered.

[0055]3-dB bandwidth is **10.5 kHz, and the rates alpha of a roll-off are the route roll-off characteristics of 0.5 for examination. A phase characteristic shall be given by ph(x)=x-sinx.
[0056]Drawing 9 shows the characteristic in case the number of group delay ripples which is the typical feature of a ceramics filter is 1, and drawing 10 shows the characteristic in case the number of group delay ripples is 2. A solid line shows a phase characteristic by drawing 9 and drawing 10, and a dashed line shows group delay frequency characteristics.
[0057]Drawing 11 is a modulation accuracy characteristic figure to a group delay ripple deviation. It is shown that a group delay ripple deviation and modulation accuracy have a relation of primary proportionality as for drawing 11. Here, it is shown clearly that the curve 112 with two ripples of degradation of modulation accuracy is smaller to the same group delay ripple deviation compared with the curve 111 with one ripple. The same result was obtained also when the number of ripples was two or more.
[0058]Since the absolute value of the amplitude of a phase becomes small so that there are many ripples when a group delay ripple deviation is equal, it is thought that it depends for modulation accuracy on the absolute value of phase amplitude instead of a group delay ripple deviation. That is, if the group delay ripple deviation is the same, a direction with many ripples is advantageous to an improvement of modulation accuracy.
[0059]From the above-mentioned analysis result, it was presumed that the factor which carries out direct influence to modulation accuracy was not a group delay ripple deviation but a phase excursion. Then, the relation between a phase characteristic and modulation accuracy is considered. 3-dB bandwidth is **10.5 kHz, the candidate for examination is the same with the case of a group delay ripple deviation, and the rates alpha of a roll-off are the route roll-off characteristics of 0.5.
[0060]Drawing 12 and drawing 13 show the phase excursion characteristic in case there is a phase excursion only in a certain frequency range, and the group delay frequency characteristics corresponding to the phase excursion (the phase normalized the field which changes linearly in the straight line of phase excursion =0, and the phase excursion characteristic expressed a changed part from the reference line).
[0061]The phase excursion when the frequency from which a phase excursion serves as the maximum without changing the form of a phase excursion was changed (that is, parallel movement of the form of a phase characteristic is carried out on a frequency axis.) asked for the relation of the frequency and modulation accuracy which take the maximum with the simulation. The result is shown in drawing 14.
[0062]As a general trend, it turns out that the influence which it has on modulation accuracy is small, so that a phase excursion separates from center frequency. Although drawing 12 and drawing 13 show the phase characteristic with the same maximum phase excursion, therefore the direction of drawing 13 presents a rapid phase change, the group delay deviation is twice [about] to drawing 12.
[0063]However, drawing 14 shows that it is the characteristic as modulation accuracy that the characteristic 142 of drawing 13 is more preferred rather than the characteristic 141 of drawing 12. This shows that it is insufficient that only a group delay deviation (what differentiated the phase about frequency) estimates modulation accuracy, when a phase excursion is equal. When a phase excursion was equal, it was checked that it may also be more effective in an improvement of modulation accuracy for a phase to change rapidly.
[0064]As stated above, in the intermediate frequency filter of this embodiment, the following matter became clear by evaluating the filter characteristics from modulation accuracy.

1. When narrowing (1) 3-dB bandwidth rather than route roll-off characteristics about an amplitude characteristic, degradation of modulation accuracy has the small one where the rate of a roll-off is larger.
[0065](2) Although route roll-off characteristics are ideals, if the zone of an amplitude characteristic is narrow to route roll-off characteristics within a 3-dB zone when separating from this characteristic and it is out of band 3 dB, degradation of modulation accuracy has the small one to route roll-off characteristics where a zone is larger.
[0066](3) The thing with the largest rate of degradation is out of band 3 dB, and is a case where a zone becomes narrow from route roll-off characteristics.
(4) When it actually constitutes a filter, it is difficult to make the rate of a roll-off or less into 0.5, and it is effective against modulation accuracy in this case. [of the amplitude characteristic within a 3 dB zone]
[0067](5) When the rate of a roll-off is equal, compared with the case where the direction where 3-dB bandwidth spreads to a reference value (**10.5 kHz) narrows, degradation of modulation accuracy has a small rate. The small filter of influence is obtained from this to frequency deviation by designing bandwidth greatly beforehand.
2. If (1) group-delay-ripple deviation is the same about group delay frequency characteristics, a direction with many ripples is advantageous to modulation accuracy. From this, it seems that modulation accuracy is related to a phase excursion.
[0068](2) The influence on modulation accuracy becomes small, so that a position with a deviation separates from the center frequency of a filter, when there is a phase excursion.
(3) When a phase excursion is equal, compared with the case where a phase changes in (a phase characteristic is steep) and a wide frequency range in the direction where a phase changes, modulation accuracy becomes good in a narrow frequency range. From this, a group delay deviation is had a feeling that modulation accuracy is not what is connected directly.
[0069]Based on the examining result of the filter characteristics for digital signal transmission from the field of the modulation accuracy evaluation described above, the resonator used length vibration mode and center of filter frequency made the eight-element ceramic ladder filter as an experiment as 450 kHz. The modulation accuracy acquired considering this ceramics filter as an intermediate frequency filter is 4.9% thru/or 6.8%, and this fully fills the practical use characteristic.
[0070]In the intermediate frequency filter in this embodiment, although the ceramics filter was explained as an example, If it is various kinds of semiconductor functional devices including a surface acoustic element and CCD, the integrated switched capacitor element, and the other elements which achieve an equivalent function, No matter what element it may use, the intermediate frequency filter shown by this embodiment and the same intermediate frequency filter can be constituted, and the same effect can be acquired.
[0071]
[Effect of the Invention]According to this invention, a frequency span including even the point over said input signal of an output signal decreasing [3 dB] as mentioned above, Based on the route roll-off filter which said input signal determined as the 3-dB bandwidth which carries out a band pass, and made the rate 0.5 of a roll-off, as the transient region characteristic between a pass band [/ in said 3 dB bandwidth], and the decay area corresponding to the outside of said 3-dB bandwidth, In said pass band, size rather than said route roll-off filter The characteristic which presents the becoming path loss, said decay area -- said route roll-off filter -- smallness -- it constituting so that it may have the characteristic which presents path loss, and, Since the

group delay frequency characteristics in a band pass field detached the peak of the ripple substantially and constituted it from center of filter frequency, including two or more ripples, When using it as an intermediate frequency filter of the communication equipment in a digital radio transmission system, the digital error rate which has outstanding filter characteristics and originates in intersymbol interference can be reduced.
[0072]Since the above-mentioned intermediate frequency filter was constituted using the piezoelectric ceramic element, the surface acoustic element, or the integration switched capacitor, in addition to the above-mentioned effect, design and manufacture can be further made easy, and it can miniaturize.
[0073]By the above, such communication equipment can be further miniaturized by using it as an intermediate frequency filter of portable communication equipment like the mobile communications cordless handset in a digital radio transmission system.

TECHNICAL FIELD

[Field of the Invention]This invention is used for a wireless-radios machine, and relates to the intermediate frequency filter which passes only the intermediate frequency signal.

PRIOR ART

[Description of the Prior Art]The main problems in digital signal transmission art are that a digital error increases by the intersymbol interference which originates in distortion of the pulse shape by which it is generated when a pulse signal passes through a transmission line, and the pulse signal receives.
[0003]Usually, the frequency spectra of a rectangular pulse have an infinite frequency component theoretically. Therefore, if it is going to receive correctly the rectangular pulse waveform transmitted through the transmission line, It is required for a transmission line to be able to transmit an infinite frequency component ideally, therefore a wide band is extremely required of the frequency characteristic over the transmission signal of a transmission line, and in addition, this will receive to an unnecessarily excessive noise component undesirably, seeing from the utilization efficiency of transmission frequency bandwidth.
[0004]If a line band is narrowed in order to decrease this noise component, a received-pulses waveform will spread in a time base direction, and it will be affected at the discernment time between the contiguity pulses of order. Therefore, intersymbol interference is small, there are few noises, namely, to equalize in the pulse shape with which a digital error rate serves as the minimum is desired.
[0005]The most fundamental band limit is use of the filter which has the ideal low-pass filter characteristic. When an impulse is impressed to this filter, a response serves as the response waveform 151 of well-known as shown in drawing 15.
[0006]In this response waveform 151, a zero appears in every T_0 (=1/2f_0) except for the peak of the center in t= 0. If interval T_0 to t=0-T_0 in this case is called Nyquist interval 152 and an impulse train is transmitted with this Nyquist interval 152, intersymbol interference will be thoroughly avoided to the momentary detection performed in the center of received pulses.
[0007]Since a fundamental wave component is intercepted, the train of impulses of an interval smaller than this Nyquist interval 152 is not transmitted by usual. That is, the bit rate corresponding to Nyquist interval 152 has given the transmission limit in the zone.

[0008]Extraordinary difficulty is followed on realizing the above ideal low-pass filter characteristics in practice. Then, in order to search for the conditions of the filter in an actual transmission line, the 1st standard of nyquist is used.
[0009]As it is indicated in drawing 16 (a) as the 1st standard of nyquist, about interception angular-frequency omega$_0$, Also as the filter characteristics 163 as applied the filter characteristics 162 of the ** symmetrical filter which has the characteristic symmetrical with ** to the filter characteristics 161 of an ideal filter, compounded them and shown in drawing 16 (b), As shown in drawing 16 (d), I hear that the intersection to the horizontal axis (omega$_0$t) of the impulse response waveform 165 does not change, and there is.
[0010]The filter characteristics shown in drawing 16 (b) and drawing 16 (c) have the characteristic that realization is possible and no intersymbol interference is to the impulse transmission of repeat frequency [of 2f] $_0$. The frequency characteristic symmetrical with ** which can be added to the filter characteristics 161 of an ideal filter exists infinitely, and the synthesizing filter characteristic which added in this way and was made also exists infinitely. The filter characteristics generally widely used among this synthesizing filter characteristic are the filter characteristics 163 shown in drawing 16 (b).
It is called roll-off spectrum and expressed with (the formula 1).

[0011]
[Equation 1]

$$H(\omega)=\begin{cases} 1 \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots 0 \leqq \omega \leqq \omega_0(1-\alpha) \\ \frac{1}{2}\left[1-\sin\left\{\frac{\pi}{2\alpha\omega_0}(\omega-\omega_0)\right\}\right] \\ \qquad\qquad\qquad\cdots\cdots\cdots\cdots\cdots \omega_0(1-\alpha) \leqq \omega \leqq \omega_0(1+\alpha) \\ 0 \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \omega \geqq \omega_0(1+\alpha) \end{cases} \quad \cdots (式1)$$

[0012]By calling alpha the rate of a roll-off here by the coefficient which shows the degree of the inclination of a band limit, and changing the value of this rate alpha of a roll-off in (0<=alpha<=1), As shown in drawing 16 (c), it is changed from the filter characteristics [in / for filter characteristics / alpha= 0] 164a before the filter characteristics 164b in alpha= 1. omega$_0$ is expressed like omega$_0$=piT$_0$ using Nyquist interval T$_0$.
[0013]Usually, it becomes the optimal transmission system characteristic for the combination of the route roll-off filter characteristic which distributed the characteristic of being expressed with the above-mentioned (formula 1) to division into equal parts at the transmitting side and the receiver of the transmission system to make a digital error rate the minimum.
[0014]In order to observe visually the received-pulses waveform containing intersymbol interference and a noise, the eye diagram (eye pattern) typically drawn on drawing 17 is convenient. An eye diagram is the waveform which restored to the digital signal sequence modulated by the random pulse by the receiver, took the synchronization by the clock pulse and described this demodulation waveform on the oscilloscope.
[0015]The opening part 171 of the waveform pattern which carried out the form of the eye near the identification point of the eye diagram shown in drawing 17 can be called an eye, and it can ask for the degree of margin of numerals discernment from this numerical aperture. Supposing there is deltaV in the direction of an oscillation axis (lengthwise direction) and the numerical

aperture of an eye has degradation of deltaT to an ideal eye in a time base direction (transverse direction), The eye numerical aperture of v_a/V_p and a time base direction is expressed with t_a/T_p, and the eye numerical aperture of the direction of an oscillation axis can evaluate the quality of the transmission system characteristic by these eye numerical apertures.

[0016]However, since it complains of the evaluation by this eye numerical aperture to human being's feeling intuitively, as qualitative observation, it is convenient, but there are some which lack in quantitative evaluation. On the other hand, as a quantitive rate scale of a digital signal transmission system, there is a vector amplitude error showing an error with the modulated wave type of an ideal. This is a value of the vector amplitude error 182 which expressed the gap from the ideal signal 181 based on the coordinates R of the amplitude/phase of ideal pi / 4 shift QPSK signal, and the coordinates S of the amplitude/phase of pi / 4 shift QPSK signal actually measured, as shown in drawing 18.

[0017]Generally, (absolute value of vector amplitude error 182)/(absolute value of the amplitude of the ideal signal 181) is called modulation accuracy, and it is considered as the rate scale in a digital signal transmission system. In the RCR (Research & Development Center of Radio System) standard, modulation accuracy is determined as less than 12.5% in the sending signal.

[0018]As mentioned above, in a digital transmission system, As most typical filter that realization of the transmission line which loses intersymbol interference to an impulse signal, and where little response of a digital error is obtained becomes important, and can realize such an impulse response, A roll-off filter is mentioned and the digital error rate resulting from intersymbol interference can be reduced also in a digital radio transmission system by using this roll-off filter as an intermediate frequency filter of the communication equipment in a digital radio transmission system.

[0019]Of course, a roll-off filter suitable for digital signal transmission described above can be easily constituted using discrete part, such as an inductor and a capacitor, and is used from the former. However, there is a limit in the miniaturization, and the LC filter constituted using such an inductor (L), a capacitor (C), etc. cannot fully satisfy the request of the time of microminiaturization of the present communication equipment, and has already become the past thing.

[0020]By then, development of the presentation called the three component systems PZT since piezoelectricity was checked in the ceramic element made from barium titanate ($BaTiO_3$). The piezoelectric ceramic material which a dielectric constant, piezoelectricity, a mechanical quality factor, temperature characteristics, etc. can choose now freely, . Compared with other piezoelectric material, the wide range characteristic is obtained by changing the presentation whose piezoelectricity is size and whose dielectric constant is size. Since it has many features which are the extremely stable low cost with mass production nature which can form shape freely, and are referred to as suitable for the miniaturization etc., it came to be widely used as a material of a resonator.

[0021]Therefore, can use this piezoelectric ceramic material as a raw material of the intermediate frequency filter of the 450-kHz belt used for digital mobile communications equipment, and as an intermediate frequency filter in digital mobile communications equipment from the former, Many ceramics filters constituted using the above-mentioned piezoelectric ceramic material are used.

EFFECT OF THE INVENTION

[Effect of the Invention]By this invention, a frequency span including even the point over said input signal of an output signal decreasing [3 dB] as mentioned above, Based on the route roll-off filter which said input signal determined as the 3-dB bandwidth which carries out a band pass, and made the rate 0.5 of a roll-off, as the transient region characteristic between a pass band [/ in said 3 dB bandwidth], and the decay area corresponding to the outside of said 3-dB bandwidth, In said pass band, size rather than said route roll-off filter The characteristic which presents the becoming path loss, said decay area -- said route roll-off filter -- smallness -- it constituted so that it might have the characteristic which presents path loss, and including two or more ripples, the group delay frequency characteristics in a band pass field detached the peak of the ripple substantially, and constituted it from center of filter frequency.
Therefore, when using it as an intermediate frequency filter of the communication equipment in a digital radio transmission system, the digital error rate which has outstanding filter characteristics and originates in intersymbol interference can be reduced.

[0072]Since the above-mentioned intermediate frequency filter was constituted using the piezoelectric ceramic element, the surface acoustic element, or the integration switched capacitor, in addition to the above-mentioned effect, design and manufacture can be further made easy, and it can miniaturize.
[0073]By the above, such communication equipment can be further miniaturized by using it as an intermediate frequency filter of portable communication equipment like the mobile communications cordless handset in a digital radio transmission system.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]However, although it is widely used from the necessity for the miniaturization and uses as the intermediate frequency filter in the mobile communications equipment in a digital radio transmission system now in the conventional intermediate frequency filter constituted by the above ceramics filters, This ceramics filter assumes a gap of the frequency by temperature characteristics etc., It is most which designed a **10.5-kHz 3-dB pass band width, provided means, such as carrying out external [of the resistor] to a resonator in order to decrease a group delay deviation, and has acquired the modulation accuracy of required **, In the case where this kind of filter is used for a digital transmission system, although the actual condition is that it is [that there is nothing] near in practical information useful to that design and manufacture and the miniaturization was completed, the design had the problem that it was difficult and manufacture was not easy.
[0023]In general radio frequency signal transmission systems, such as a digital signal transmission system using a radio frequency signal, In [as for the above ceramics filters, it is common to be used only for a receiver as an intermediate frequency filter, therefore] a digital radio transmission system, Realizing route roll-off characteristics by the above-mentioned problem in the receiver for which the intermediate frequency filter which comprised above ceramics filters is used also had the problem of being very difficult.
[0024]When this invention solves the above-mentioned problem and it uses it as an intermediate frequency filter of the communication equipment in a digital radio transmission system, The digital error rate which has outstanding filter characteristics and originates in intersymbol interference can be reduced, and the intermediate frequency filter which can make design and manufacture easy further, and can be miniaturized is provided.

MEANS

[Means for Solving the Problem]In order to solve an aforementioned problem, the intermediate frequency filter of this invention according to claim 1, A frequency span which chooses and outputs a specific frequency component of an input signal, and includes even a point over said input signal of the output signal decreasing [3 dB], Based on a route roll-off filter which said input signal determined as the 3-dB bandwidth which carries out a band pass, and made the rate 0.5 of a roll-off, as the transient region characteristic between a pass band [/ in said 3 dB bandwidth], and a decay area corresponding to outside of said 3-dB bandwidth, said pass band -- said route roll-off filter -- size -- the characteristic which presents path loss, and said decay area -- said route roll-off filter -- smallness -- it constitutes so that it may have the characteristic which presents path loss.

[0026]According to this composition, when it is used as an intermediate frequency filter of communication equipment in a digital radio transmission system, it acts so that a digital error rate resulting from intersymbol interference may be reduced.

[0027]

[Embodiment of the Invention]Hereafter, the intermediate frequency filter in which an embodiment of the invention is shown is explained, referring to Drawings.

[0028]As conventional technology explained, when using a ceramics filter made from a piezoelectric ceramic material as an intermediate frequency filter of the communication equipment in a digital radio transmission system, From the Reason the design and manufacture for reducing the digital error rate which has outstanding filter characteristics and originates in intersymbol interference are not easy. In the ceramics filter of the 450-kHz belt used for digital mobile communications equipment, the actual condition is that realization of route roll-off characteristics without intersymbol interference is very difficult.

[0029]Therefore, by investigating the influence which it has on the transmission system characteristic when filter characteristics separate from route roll-off characteristics here, The result of having examined the desirable characteristic of the ceramics filter is explained to the case where a ceramics filter is used as above intermediate frequency filters.

[0030]Evaluation of filter characteristics was performed by searching for the modulation accuracy showing the gap from an ideal signal (state without intersymbol interference), i.e., (absolute value of vector amplitude error)/, (absolute value of ideal signal amplitude) in a simulation.

[0031]First, when modulation accuracy estimates filter characteristics, the outline procedures of the modulation accuracy simulation used for the evaluation are enumerated below, and are explained briefly. The procedure of this modulation accuracy simulation creates random data using 15 steps of (1) M sequence.

[0032](2) Change binary code into a gray code.
(3) Map a gray code in pi / 4 shift QPSK.
(4) Calculate the impulse response of a route roll-off filter.

[0033](5) Create the repetition waveform for FFT.
(6) Perform a convolution integral.
(7) Pass a linear amplifier and amplify.

[0034](8) Ask for the maximum, the minimum, and average power.
(9) Ask for a frequency domain by FFT.

(10) Create the data for a plot in a frequency domain.
[0035](11) Pass a receiving filter in a frequency domain.
(12) Search for a segment of time by FFT.
(13) Plot data on a phase plane.
[0036](14) Ask for an amplitude error and a phase error.
(15) Calculate modulation accuracy.
(16) Change inclination of the phase of a filter.
** -- it becomes like. Here, integration of (6) is performed by passing a route roll-off filter, the characteristic of the receiving filter of (11) is incorporated from a ceramics filter design program or data measuring, and the filter characteristics are given with amplitude and a phase. In pi / 4 shift QPSK modulation, in order to apply abnormal conditions by relative displacement of a phase, as for inclination of the phase of a filter, whether only in which, not a problem but the phase has shifted from the straight line poses a problem. For this reason, a phase is incorporated with the straight line used as a standard, and is given with the difference of data. The slope of a line used as a standard shall repeat (11) - (16), and shall make modulation accuracy the minimum.
[0037]The combination of the various filter characteristics which show drawing 1 - drawing 5 the above-mentioned simulation was followed. By the case where drawing 2 is between transmission and reception, and it has roll-off characteristics by the case where drawing 1 is between transmission and reception, and it has route roll-off characteristics. By the case where a receiver filter has an A-weighting function with route roll-off characteristics, a transmitting side filter drawing 3. In the case where, as for drawing 4, a receiver filter has B weighting with route roll-off characteristics in a transmitting side filter, drawing 5 is a case where a transmitting side filter has route roll-off characteristics, and a receiver filter has C weighting. The actual measurement of the modulation accuracy about these filter characteristics and the result of the simulation were shown as compared with (Table 1).
[0038]
[Table 1]

	送受信間ルートロールオフ	送受信間ロールオフ特性	送信側ルートロールオフフィルタ		
			受信側A特性	受信側B特性	受信側C特性
実　　測	13.8%	0.7%	7.0%	7.5%	12.6%
シミュレーション	14.2%	0.0%	6.9%	8.0%	11.8%

（表1）

[0039]this (Table 1) -- from -- it is admitted that the actual measurement and simulation value of modulation accuracy are well in agreement so that clearly. Therefore, suppose that evaluation of the filter characteristics in this embodiment is performed with the simulation of modulation accuracy.
[0040]In order to miniaturize a 450-kHz belt ceramics filter, it is effective to use the rectangular plate vibrator using the length vibration mode of a piezoelectric transducer as a filter element. However, since the interval of resonance frequency-antiresonant frequency is small compared with spread vibration when using length vibration mode, the problem that the design of the filter of a broadband is difficult occurs. Then, the influence which change of bandwidth has on modulation accuracy was considered.

[0041]On the occasion of this examination, a transmission system is used with 3dB bandwidth =**10.5kHz, The 3-dB bandwidth of the route roll-off filter which gives the characteristic as an intermediate frequency filter of a receiving system, and the rate alpha of a roll-off were changed using the intermediate frequency filter which has the characteristic of the route roll-off filter made into the rate alpha= 0.5 of a roll-off, and the modulation accuracy was evaluated. It corresponds to the ceramics filter which the route roll-off filter of a receiving system examines. Here, the characteristic of each filter shall have the linear phase characteristic. The examining result by the above conditions is shown in ((Table 2 and 3)).
[0042]
[Table 2]

ロールオフ率 α	帯域幅 ±8.5kHz	帯域幅 ±9.0kHz	帯域幅 ±9.5kHz	帯域幅 ±10.0kHz	帯域幅 ±10.5kHz
0.5	18.1%	12.2%	7.2%	3.2%	0.0%
0.6	14.9%	9.9%	5.9%	2.7%	0.3%
0.7	12.4%	8.3%	5.0%	2.3%	0.6%
0.8	10.5%	7.1%	4.4%	2.2%	1.4%
0.9	9.1%	6.2%	3.9%	2.3%	1.9%
1.0	7.8%	5.4%	3.6%	2.5%	2.4%

（表2）

[0043]
[Table 3]

ロールオフ率 α	帯域幅 ±11.0kHz	帯域幅 ±11.5kHz	帯域幅 ±12.0kHz	帯域幅 ±12.5kHz	帯域幅 ±13.0kHz
0.5	2.6%	4.7%	6.4%	7.8%	9.0%
0.6	2.2%	4.0%	5.5%	6.8%	7.9%
0.7	2.1%	3.6%	4.9%	6.0%	7.0%
0.8	2.2%	3.4%	4.6%	5.6%	6.4%
0.9	2.6%	3.5%	4.5%	5.4%	6.1%
1.0	3.0%	3.8%	4.6%	5.4%	6.0%

（表3）

[0044]In (Table 2) and the (Table 3), when 3-dB bandwidth is **10.5 kHz, modulation accuracy serves as best, Other than this, even when jam bandwidth of 3 dB is larger than it, and even when small, it is shown that modulation accuracy deteriorates, and it is also shown that these things can say similarly about all the rates of a roll-off.
[0045]Since the direction which makes 3-dB bandwidth large is smaller than the direction to narrow, the degree of degradation is understood that the deterioration degree by dispersion in frequency is small advantageous when 3-dB bandwidth is designed width. Speaking of the rate of a roll-off, the optimum value of the rate of a roll-off which makes modulation accuracy best exists with 3-dB bandwidth. When narrowing 3-dB bandwidth, there is a tendency for the

degradation rate of modulation accuracy to decrease, by enlarging the rate of a roll-off.
[0046]Thus, when 3-dB bandwidth is narrow, it is possible to reduce degradation of modulation accuracy by enlarging the rate of a roll-off, but it is guessed that the frequency drift by temperature characteristics has an adverse effect on modulation accuracy compared with the case where 3-dB bandwidth is wide.
[0047]Generally, it is thought that the energy distribution of a transmission signal is concentrated in the 3-dB bandwidth of a filter. Therefore, when the filter characteristics in 3-dB bandwidth change, naturally change of modulation accuracy is expected.
[0048]Drawing 6 and drawing 7 are the characteristic figures of the low-pass filter which is going to evaluate change of modulation accuracy. Drawing 6 and drawing 7 are based on the same low-pass filter, and are a characteristic figure of the various low-pass filters to which the internal and external rate of a roll-off of the 3-dB bandwidth was changed.
[0049]These filter characteristics are based on the route roll-off filter of 3dB bandwidth =10.5kHz and the rate alpha= 0.5 of a roll-off. Drawing 6 shows filter characteristics when drawing 7 changes the rate alpha of a roll-off into 0, 0.25, 0.75, and 1.0 with the frequency band of a high region rather than 10.5 kHz, when the rate alpha of a roll-off is changed into 0, 0.25, 0.75, and 1.0 with a low-pass frequency band rather than 10.5 kHz. However, it assumes that a phase is constant and group delay frequency characteristics are not taken into consideration. The dashed line 61 in drawing 6 and drawing 7 shows the filter characteristics of the route roll-off filter of the rate alpha= 0.5 of a roll-off in a transmission system, respectively.
[0050]The evaluation result of the modulation index in the transmission system of the filter characteristics shown in drawing 6 and drawing 7 is shown in drawing 8. Drawing 8 the rate of a roll-off in the modulation accuracy characteristic 81 at the time of making it change within 3-dB bandwidth. In the modulation accuracy characteristic 82 at the time of degradation of modulation accuracy becoming less than the case where the rate alpha of a roll-off becomes smaller [it / to become larger than 0.5], a little, and changing the rate of a roll-off out of 3-dB bandwidth. It means that degradation of modulation accuracy becomes less than the case where the rate alpha of a roll-off becomes smaller [it / to become larger than 0.5], remarkably.
[0051]When in other words it is a filter whose 3-dB bandwidth is **10.5 kHz, The transmission quantity in 3-dB bandwidth to the transmission quantity of the route roll-off characteristics of the rate 0.5 of a roll-off the direction of few filter characteristics, Compared with many filter characteristics, degradation of modulation accuracy is small, and degradation of modulation accuracy has the small transmission quantity besides 3-dB bandwidth compared with filter characteristics with few many filter characteristics to the transmission quantity of the route roll-off characteristics of the rate 0.5 of a roll-off. The degree of degradation is remarkable when transmission quantity out of band 3 dB becomes less than the transmission quantity of the route roll-off characteristics of the rate 0.5 of a roll-off.
[0052]Since the filter characteristics with the small rate alpha of a roll-off are the things of a very steep operating characteristic, realization is difficult, and the actual rate of a roll-off becomes large easilier than 0.5. Therefore, the characteristic in 3-dB bandwidth becomes important from a viewpoint of raising modulation accuracy.
[0053]So far, although the examining result about the amplitude characteristic of a filter has been explained, the analysis result about group delay frequency characteristics is explained henceforth. The group delay frequency characteristics of a ceramics filter are absolutely governed by group delay and the group delay ripple deviation. By any means, group delay specifies the timing of the transmission and reception in Transmission Systems Division, and

does not affect modulation accuracy. On the other hand, a group delay ripple deviation causes waveform distortion at the time of a signal passing a filter, and has direct influence on modulation accuracy.
[0054]The number of group delay ripples in the 3-dB bandwidth of a filter (the number of the mountains of the group delay on a frequency axis) changes a little with designing methods. In regulation of the present group delay frequency characteristics, although the ripple deviation is defined, it is not defined to the number of ripples. Here, the relation between a group delay ripple deviation and modulation accuracy is considered, and when a ripple deviation is still more nearly equal, and the numbers of ripples differ, the influence modulation accuracy is influenced is considered.
[0055]3-dB bandwidth is **10.5 kHz, and the rates alpha of a roll-off are the route roll-off characteristics of 0.5 for examination. A phase characteristic shall be given by ph(x)=x-sinx.
[0056]Drawing 9 shows the characteristic in case the number of group delay ripples which is the typical feature of a ceramics filter is 1, and drawing 10 shows the characteristic in case the number of group delay ripples is 2. A solid line shows a phase characteristic by drawing 9 and drawing 10, and a dashed line shows group delay frequency characteristics.
[0057]Drawing 11 is a modulation accuracy characteristic figure to a group delay ripple deviation. It is shown that a group delay ripple deviation and modulation accuracy have a relation of primary proportionality as for drawing 11. Here, it is shown clearly that the curve 112 with two ripples of degradation of modulation accuracy is smaller to the same group delay ripple deviation compared with the curve 111 with one ripple. The same result was obtained also when the number of ripples was two or more.
[0058]Since the absolute value of the amplitude of a phase becomes small so that there are many ripples when a group delay ripple deviation is equal, it is thought that it depends for modulation accuracy on the absolute value of phase amplitude instead of a group delay ripple deviation. That is, if the group delay ripple deviation is the same, a direction with many ripples is advantageous to an improvement of modulation accuracy.
[0059]From the above-mentioned analysis result, it was presumed that the factor which carries out direct influence to modulation accuracy was not a group delay ripple deviation but a phase excursion. Then, the relation between a phase characteristic and modulation accuracy is considered. 3-dB bandwidth is **10.5 kHz, the candidate for examination is the same with the case of a group delay ripple deviation, and the rates alpha of a roll-off are the route roll-off characteristics of 0.5.
[0060]Drawing 12 and drawing 13 show the phase excursion characteristic in case there is a phase excursion only in a certain frequency range, and the group delay frequency characteristics corresponding to the phase excursion (the phase normalized the field which changes linearly in the straight line of phase excursion =0, and the phase excursion characteristic expressed a changed part from the reference line).
[0061]The phase excursion when the frequency from which a phase excursion serves as the maximum without changing the form of a phase excursion was changed (that is, parallel movement of the form of a phase characteristic is carried out on a frequency axis.) asked for the relation of the frequency and modulation accuracy which take the maximum with the simulation. The result is shown in drawing 14.
[0062]As a general trend, it turns out that the influence which it has on modulation accuracy is small, so that a phase excursion separates from center frequency. Although drawing 12 and drawing 13 show the phase characteristic with the same maximum phase excursion, therefore the

direction of drawing 13 presents a rapid phase change, the group delay deviation is twice [about] to drawing 12.
[0063]However, drawing 14 shows that it is the characteristic as modulation accuracy that the characteristic 142 of drawing 13 is more preferred rather than the characteristic 141 of drawing 12. This shows that it is insufficient that only a group delay deviation (what differentiated the phase about frequency) estimates modulation accuracy, when a phase excursion is equal. When a phase excursion was equal, it was checked that it may also be more effective in an improvement of modulation accuracy for a phase to change rapidly.
[0064]As stated above, in the intermediate frequency filter of this embodiment, the following matter became clear by evaluating the filter characteristics from modulation accuracy.
1. When narrowing (1) 3-dB bandwidth rather than route roll-off characteristics about an amplitude characteristic, degradation of modulation accuracy has the small one where the rate of a roll-off is larger.
[0065](2) Although route roll-off characteristics are ideals, if the zone of an amplitude characteristic is narrow to route roll-off characteristics within a 3-dB zone when separating from this characteristic and it is out of band 3 dB, degradation of modulation accuracy has the small one to route roll-off characteristics where a zone is larger.
[0066](3) The thing with the largest rate of degradation is out of band 3 dB, and is a case where a zone becomes narrow from route roll-off characteristics.
(4) When it actually constitutes a filter, it is difficult to make the rate of a roll-off or less into 0.5, and it is effective against modulation accuracy in this case. [of the amplitude characteristic within a 3 dB zone]
[0067](5) When the rate of a roll-off is equal, compared with the case where the direction where 3-dB bandwidth spreads to a reference value (**10.5 kHz) narrows, degradation of modulation accuracy has a small rate. The small filter of influence is obtained from this to frequency deviation by designing bandwidth greatly beforehand.
2. If (1) group-delay-ripple deviation is the same about group delay frequency characteristics, a direction with many ripples is advantageous to modulation accuracy. From this, it seems that modulation accuracy is related to a phase excursion.
[0068](2) The influence on modulation accuracy becomes small, so that a position with a deviation separates from the center frequency of a filter, when there is a phase excursion.
(3) When a phase excursion is equal, compared with the case where a phase changes in (a phase characteristic is steep) and a wide frequency range in the direction where a phase changes, modulation accuracy becomes good in a narrow frequency range. From this, a group delay deviation is had a feeling that modulation accuracy is not what is connected directly.
[0069]Based on the examining result of the filter characteristics for digital signal transmission from the field of the modulation accuracy evaluation described above, the resonator used length vibration mode and center of filter frequency made the eight-element ceramic ladder filter as an experiment as 450 kHz. The modulation accuracy acquired considering this ceramics filter as an intermediate frequency filter is 4.9% thru/or 6.8%, and this fully fills the practical use characteristic.
[0070]In the intermediate frequency filter in this embodiment, although the ceramics filter was explained as an example, If it is various kinds of semiconductor functional devices including a surface acoustic element and CCD, the integrated switched capacitor element, and the other elements which achieve an equivalent function, No matter what element it may use, the

intermediate frequency filter shown by this embodiment and the same intermediate frequency filter can be constituted, and the same effect can be acquired.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The route roll-off-characteristics figure between transmission and reception of the intermediate frequency filter of an embodiment of the invention
[Drawing 2]The roll-off-characteristics figure between transmission and reception in the embodiment
[Drawing 3]The transmitting side route roll-off and receiver A-weighting function figure in the embodiment
[Drawing 4]The transmitting side route roll-off and receiver B weighting figure in the embodiment
[Drawing 5]The transmitting side route roll-off and receiver C weighting figure in the embodiment
[Drawing 6]The characteristic figure of the low-pass filter used for evaluation of modulation accuracy change
[Drawing 7]The characteristic figure of another low-pass filter used for the evaluation
[Drawing 8]The modulation accuracy characteristic figure to the rate of a roll-off
[Drawing 9]A group-delay-frequency-characteristics figure in case the number of group delay ripples is one piece
[Drawing 10]A group-delay-frequency-characteristics figure in case the number of group delay ripples is two pieces
[Drawing 11]The modulation accuracy characteristic figure to a group delay ripple deviation
[Drawing 12]A phase excursion and a group-delay-frequency-characteristics figure in case the specific frequency range has a loose phase excursion
[Drawing 13]A phase excursion and a group-delay-frequency-characteristics figure in case the specific frequency range has a rapid phase excursion
[Drawing 14]The related figure of the phase excursion maximum frequency and modulation accuracy
[Drawing 15]The impulse response waveform figure of an ideal low-pass filter
[Drawing 16]The explanatory view of the roll-off filter addition to an ideal low-pass filter
[Drawing 17]The mimetic diagram of an eye diagram
[Drawing 18]The explanatory view of the vector amplitude error which defines modulation accuracy
[Description of Notations]
61 Standard route roll-off filter
81 The modulation accuracy curve within 3dB zone
82 A modulation accuracy curve out of band 3 dB

[Translation done.]

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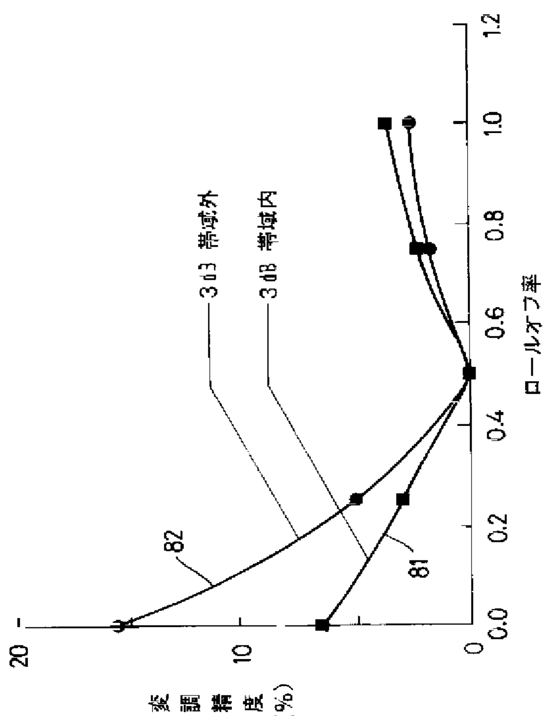
(54)【発明の名称】　中間周波フィルタ

(57)【要約】

【課題】　設計および製造を容易にしかつ小型化することができる中間周波フィルタを提供する。

【解決手段】　出力信号の入力信号に対する３ｄＢ減衰点までを含む周波数幅を、入力信号が帯域通過する３ｄＢ帯域幅と定め、ロールオフ率０．５としたルートロールオフフィルタに基づいて、３ｄＢ帯域幅内に対応する通過域と３ｄＢ帯域幅外に対応する減衰域との間の遷移域特性として、通過域ではルートロールオフフィルタよりも大なる伝送損失を呈する特性と、減衰域ではルートロールオフフィルタよりも小なる伝送損失を呈する特性とを有するよう構成する。



【特許請求の範囲】

【請求項１】　入力信号の特定周波数成分を選択して出力し、その出力信号の前記入力信号に対する３ｄＢ減衰点までを含む周波数幅を、前記入力信号が帯域通過する３ｄＢ帯域幅と定め、ロールオフ率０．５としたルートロールオフフィルタに基づいて、前記３ｄＢ帯域幅内に対応する通過域と前記３ｄＢ帯域幅外に対応する減衰域との間の遷移域特性として、前記通過域では前記ルートロールオフフィルタよりも大なる伝送損失を呈する特性と、前記減衰域では前記ルートロールオフフィルタよりも小なる伝送損失を呈する特性とを有するよう構成した中間周波フィルタ。

【請求項２】　入力信号の特定周波数成分を選択して出力し、その出力信号の前記入力信号に対する３ｄＢ減衰点までを含む周波数幅を、前記入力信号が帯域通過する３ｄＢ帯域幅と定めたルートロールオフフィルタの特性が得られる中間周波フィルタであって、当該中間周波フィルタにおける３ｄＢ帯域幅が±８．５ＫＨｚないし±１３．０ＫＨｚであり、かつ、ロールオフ率が０．９ないし１．０となるように構成した中間周波フィルタ。

【請求項３】　入力信号の特定周波数成分を選択して出力し、その出力信号の前記入力信号に対する３ｄＢ減衰点までを含む周波数幅を、前記入力信号が帯域通過する３ｄＢ帯域幅と定めたルートロールオフフィルタの特性が得られる中間周波フィルタであって、当該中間周波フィルタにおける３ｄＢ帯域幅が±９．０ＫＨｚないし±１３．０ＫＨｚであり、かつ、ロールオフ率が０．６ないし１．０となるように構成した中間周波フィルタ。

【請求項４】　入力信号の特定周波数成分を選択して出力し、その出力信号の前記入力信号に対する３ｄＢ減衰点までを含む周波数幅を、前記入力信号が帯域通過する３ｄＢ帯域幅と定めたルートロールオフフィルタの特性が得られる中間周波フィルタであって、当該中間周波フィルタにおける３ｄＢ帯域幅が±９．５ＫＨｚないし±１３．０ＫＨｚであり、かつ、ロールオフ率が０．５ないし１．０となるように構成した中間周波フィルタ。

【請求項５】　入力信号の特定周波数成分を選択して出力し、その出力信号の前記入力信号に対する３ｄＢ減衰点までを含む周波数幅を、前記入力信号が帯域通過する３ｄＢ帯域幅と定めたルートロールオフフィルタの特性が得られる中間周波フィルタであって、当該中間周波フィルタにおける３ｄＢ帯域幅内の群遅延特性が複数個のリップルを有する中間周波フィルタ。

【請求項６】　入力信号の特定周波数成分を選択して出力し、その出力信号の前記入力信号に対する３ｄＢ減衰点までを含む周波数幅を、前記入力信号が帯域通過する３ｄＢ帯域幅と定めたルートロールオフフィルタの特性が得られる中間周波フィルタであって、当該中間周波フィルタにおける３ｄＢ帯域幅内の群遅延特性が複数個のリップルを有し、そのリップルのピークが当該中間周波フィルタの中心周波数以外の周波数に位置するようにした中間周波フィルタ。

【請求項７】　群遅延特性のリップルのピークを、当該中間周波フィルタにおける３ｄＢ帯域幅の２５％ないし５０％に相当する周波数だけ、その３ｄＢ帯域幅の低域側に位置させた請求項６に記載の中間周波フィルタ。

【請求項８】　群遅延特性のリップルのピークを、当該中間周波フィルタにおける３ｄＢ帯域幅の２５％ないし５０％に相当する周波数だけ、その３ｄＢ帯域幅の高域側に位置させた請求項６に記載の中間周波フィルタ。

【請求項９】　群遅延特性のリップルのピークと当該中間周波フィルタの中心周波数との離間周波数幅を、当該中間周波フィルタにおける３ｄＢ帯域幅の２５％ないし５０％に相当する周波数幅とした請求項６に記載の中間周波フィルタ。

【請求項１０】　圧電セラミックス素子を使用して構成した請求項１から請求項９のいずれかに記載の中間周波フィルタ。

【請求項１１】　弾性表面波素子を使用して構成した請求項１から請求項９のいずれかに記載の中間周波フィルタ。

【請求項１２】　集積化されたスイッチトキャパシタを使用して構成した請求項１から請求項９のいずれかに記載の中間周波フィルタ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、無線通信機器に使用され、その中間周波信号のみを通過させる中間周波フィルタに関するものである。

【０００２】

【従来の技術】ディジタル信号伝送技術における主要な問題点は、パルス信号が伝送路を通過する際に発生するパルス波形の歪に起因して、そのパルス信号が受ける符号間干渉によって、符号誤りが増加することである。

【０００３】通常、方形パルスの周波数スペクトラムは理論的には無限の周波数成分を持っている。従って、伝送路を通じて送信された方形パルス波形を正確に受信しようとすると、理想的には伝送路が無限の周波数成分を伝送できることが必要であり、そのため、伝送路の伝送信号に対する周波数特性には極めて広い帯域が要求され、これは伝送周波数帯域の利用効率上から見て好ましくなく、加えて不要に余分なノイズ成分まで受信することになる。

【０００４】このノイズ成分を減少させるために伝送路帯域を狭くすると、受信パルス波形が時間軸方向に広がり、前後の隣接パルス間の識別時点に影響を与える。したがって、符号間干渉が小さく、かつノイズが少ない、すなわち、符号誤り率が最小となるパルス波形に等化することが望まれる。

【０００５】最も基本的な帯域制限は理想低域フィルタ

特性を有するフィルタの使用である。このフィルタにインパルスを印加したときの応答は、図１５に示すような周知の応答波形１５１となる。

【０００６】この応答波形１５１においては、ｔ＝０における中央のピークを除き、T_0（＝１／２f_0）ごとに零点が現われる。この場合のｔ＝０～T_0 までの間隔T_0をナイキスト間隔１５２と呼び、このナイキスト間隔１５２でインパルス列を送信すると、受信パルスの中央で行われる瞬間的検出に対して符号間干渉は完全に避けられる。

【０００７】このナイキスト間隔１５２よりも小さい間隔のパルス列は、基本波成分が遮断されるので、通常では伝送されない。すなわち、ナイキスト間隔１５２に対応するビットレートはその帯域での伝送限界を与えている。

【０００８】実際上は、上記のような理想低域フィルタ特性を実現するには非常な困難をともなう。そこで、現実の伝送路におけるフィルタの条件を求めるには、ナイキストの第１基準を利用する。

【０００９】ナイキストの第１基準とは、図１６（ａ）に示すように、遮断角周波数ω_0 に関し、奇対称な特性を有する奇対称フィルタのフィルタ特性１６２を理想フィルタのフィルタ特性１６１に加えて合成し、図１６（ｂ）に示すようなフィルタ特性１６３としても、図１６（ｄ）に示すように、インパルス応答波形１６５の横軸（ω_0 ｔ）に対する交点は変わらないということである。

【００１０】図１６（ｂ）および図１６（ｃ）に示すフィルタ特性は実現可能であって、繰返し周波数２f_0 のインパルス伝送に対し符号間干渉がないという特性を持つ。理想フィルタのフィルタ特性１６１に付加できる奇対称な周波数特性は無限に存在し、このように付加してできた合成フィルタ特性も無限に存在する。この合成フィルタ特性のうちで一般に広く使用されるフィルタ特性は、図１６（ｂ）に示すフィルタ特性１６３であり、ロールオフスペクトラムと呼ばれ、（式１）で表わされる。

【００１１】

【数１】

$$
H(\omega)=\begin{cases}
1 & \cdots\cdots\ 0 \leqq \omega \leqq \omega_0(1-\alpha) \\
\dfrac{1}{2}\left[1-\sin\left\{\dfrac{\pi}{2\alpha\omega_0}(\omega-\omega_0)\right\}\right] & \cdots\cdots\ \omega_0(1-\alpha) \leqq \omega \leqq \omega_0(1+\alpha) \\
0 & \cdots\cdots\ \omega \geqq \omega_0(1+\alpha)
\end{cases}
\quad \cdots\text{（式１）}
$$

【００１２】ここで、αは帯域制限の傾斜の度合を示す係数でロールオフ率と呼ばれ、このロールオフ率αの値を（$0 \leqq \alpha \leqq 1$）の範囲で変化させることにより、図１６（ｃ）に示すように、フィルタ特性を$\alpha=0$におけるフィルタ特性１６４ａから$\alpha=1$におけるフィルタ特性１６４ｂまでの間で変化させられる。また、ω_0 は、ナイキスト間隔T_0 を用いて、$\omega_0 = \pi T_0$ のように表わされる。

【００１３】通常、上記の（式１）で表わされる特性を、伝送系の送信側および受信側に等分に分配したルートロールオフフィルタ特性の組み合わせが符号誤り率を最小にするための最適伝送系特性になる。

【００１４】符号間干渉およびノイズを含む受信パルス波形を視覚的に観測するには、図１７に模式的に描いたアイダイヤグラム（アイパターン）が便利である。アイダイヤグラムとは、ランダムパルスによって変調されたディジタル信号列を受信側で復調し、この復調波形をクロックパルスで同期をとりオシロスコープ上に描出した波形である。

【００１５】図１７に示すアイダイヤグラムの識別点付近の目の形をした波形パターンの開口部分１７１をアイと呼び、この開口率から符号識別の余裕度を求めることができる。アイの開口率は、理想的なアイに対し、振幅軸方向（縦方向）でΔＶ、時間軸方向（横方向）でΔＴの劣化があるとすると、振幅軸方向のアイ開口率はv_a／V_p 、時間軸方向のアイ開口率はt_a ／T_p で表わされ、これらのアイ開口率によって、伝送系特性の良否を評価することができる。

【００１６】しかし、このアイ開口率による評価は、人間の感覚に直感的に訴えるので定性的観測としては便利であるが、定量的評価に欠けるものがある。一方、ディジタル信号伝送系の定量的な評価尺度としては、理想の変調波形との誤差を表わすベクトル振幅誤差がある。これは、図１８に示すように、理想的なπ／４シフトＱＰＳＫ信号の振幅／位相の座標Ｒと、実際に測定されたπ／４シフトＱＰＳＫ信号の振幅／位相の座標Ｓをもとに、理想信号１８１からのずれを表わしたベクトル振幅誤差１８２の値である。

【００１７】一般に、（ベクトル振幅誤差１８２の絶対値）／（理想信号１８１の振幅の絶対値）を変調精度と呼び、ディジタル信号伝送系における評価尺度としている。ＲＣＲ（ Research & Development Center of Radio System ）規格では、送信信号において変調精度が１２．５％以内と定められている。

して少ないフィルタ特性の方が、多いフィルタ特性に比べて変調精度の劣化は小さく、３ｄＢ帯域幅外の伝送量がロールオフ率０．５のルートロールオフ特性の伝送量に対し多いフィルタ特性の方が、少ないフィルタ特性に比べて変調精度の劣化は小さい。劣化の度合は、３ｄＢ帯域外の伝送量がロールオフ率０．５のルートロールオフ特性の伝送量よりも少なくなる場合に著しい。

【００５２】ロールオフ率αの小さいフィルタ特性は、非常に急峻な遮断特性のものであるから実現は難しく、実際のロールオフ率は０．５よりも大となりやすい。したがって、３ｄＢ帯域幅内の特性が変調精度を高める観点から重要となる。

【００５３】ここまでは、フィルタの振幅特性についての検討結果を説明してきたが、以降、群遅延特性についての解析結果を説明する。セラミックフィルタの群遅延特性は、絶対群遅延時間と群遅延リップル偏差によって支配される。絶対群遅延時間は、伝送システムにおける送受信のタイミングを規定するものであって、変調精度には影響を及ぼさない。これに対し、群遅延リップル偏差は、信号がフィルタを通過する際の波形歪の原因となり、変調精度に直接的な影響を与える。

【００５４】フィルタの３ｄＢ帯域幅内の群遅延リップル数（周波数軸上での群遅延の山の数）は、設計手法によって若干異なる。現在の群遅延特性の規定では、リップル偏差は定められているが、リップル数までは定められていない。ここでは、群遅延リップル偏差と変調精度の関係を検討し、さらに、リップル偏差が等しい場合、リップル数が異なるときに変調精度が受ける影響について検討する。

【００５５】検討対象は、３ｄＢ帯域幅が±１０．５ＫＨｚ、ロールオフ率αが０．５のルートロールオフ特性である。また、位相特性は、ｐｈ（ｘ）＝ｘ－ｓｉｎｘで与えるものとした。

【００５６】図9はセラミックフィルタの典型的な特徴であるところの群遅延リップル数が１の場合の特性を示し、図１０は群遅延リップル数が２の場合の特性を示す。図9、図１０にて、実線は位相特性を示し、破線は群遅延特性を示す。

【００５７】図１１は群遅延リップル偏差に対する変調精度特性図である。図１１は群遅延リップル偏差と変調精度は１次比例の関係にあることを示している。ここで、リップル数２の曲線１１２の方が、リップル数１の曲線１１１に比べ、同じ群遅延リップル偏差に対して変調精度の劣化が小さいことが明瞭に示されている。リップル数が２以上の場合も同様の結果が得られた。

【００５８】群遅延リップル偏差が等しい場合、リップル数が多いほど位相の振幅の絶対値は小さくなることから、変調精度は、群遅延リップル偏差ではなく、位相振幅の絶対値に依存すると考えられる。すなわち、群遅延リップル偏差が同じであれば、リップル数の多い方が変調精度の改善に有利である。

【００５９】上述の解析結果から、変調精度に直接影響する要因は群遅延リップル偏差ではなく、位相偏差であると推定された。そこで、位相特性と変調精度の関係を検討する。検討対象は、群遅延リップル偏差の場合と同じく、３ｄＢ帯域幅が±１０．５ＫＨｚ、ロールオフ率αが０．５のルートロールオフ特性である。

【００６０】図１２、図１３は、ある周波数範囲のみに位相偏差がある場合の位相偏差特性と、その位相偏差に対応する群遅延特性を示す（位相偏差特性は、位相が直線的に変化する領域を位相偏差＝０の直線で基準化し、その基準直線からの変化分を表わした）。

【００６１】位相偏差の形を変えずに位相偏差が最大となる周波数を変化させたとき（すなわち、位相特性の形を周波数軸上で並行移動させる。）の位相偏差が最大値をとる周波数と変調精度の関係をシミュレーションによって求めた。その結果を図１４に示す。

【００６２】傾向として、位相偏差が中心周波数から離れるほど、変調精度に与える影響が小さいことがわかる。図１２、図１３は、同じ最大位相偏差をもつ位相特性を示しているが、図１３の方が急激な位相変化を呈する故に、その群遅延偏差は図１２に対し、約２倍となっている。

【００６３】ところが、図１４は、図１２の特性１４１よりも図１３の特性１４２の方が変調精度としては好ましい特性であることを示している。このことから、位相偏差が等しい場合、変調精度を群遅延偏差（位相を周波数について微分したもの）のみで評価するのは不十分であることが分かる。さらに、位相偏差が等しい場合、位相が急激に変化した方が変調精度の改善に有効である場合があることも確認された。

【００６４】以上述べたように、本実施の形態の中間周波フィルタにおいて、そのフィルタ特性を変調精度から評価することによって、下記事項が明らかになった。

１．振幅特性については

（１）３ｄＢ帯域幅をルートロールオフ特性よりも狭める場合、ロールオフ率の大きい方が変調精度の劣化は小さい。

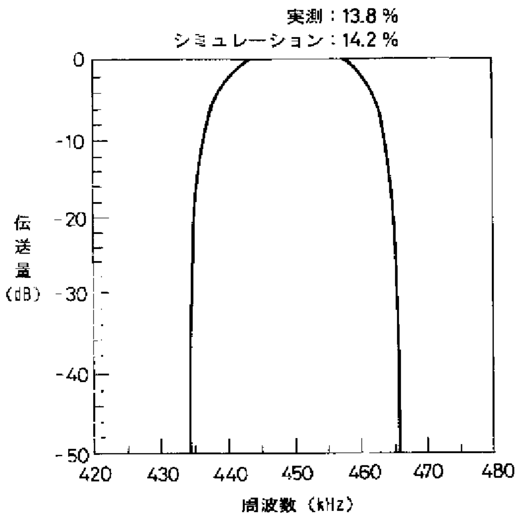
【００６５】（２）振幅特性はルートロールオフ特性が理想であるが、この特性から外れる場合、３ｄＢ帯域内では、ルートロールオフ特性に対して帯域が狭く、３ｄＢ帯域外では、ルートロールオフ特性に対して帯域が広い方が変調精度の劣化は小さい。

【００６６】（３）最も劣化の割合が大きいのは、３ｄＢ帯域外でルートロールオフ特性より帯域が狭くなる場合である。

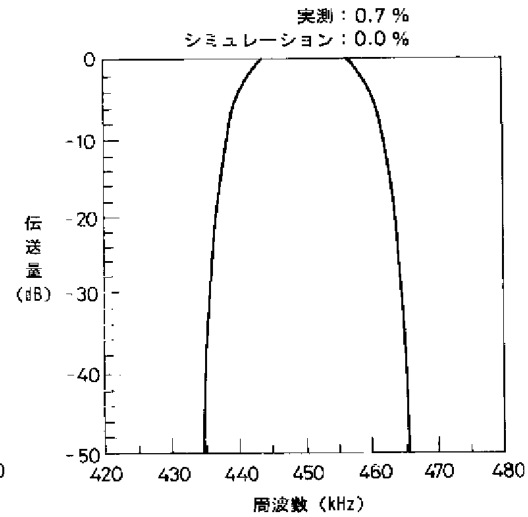
（４）実際にフィルタを構成する場合、ロールオフ率を０．５以下にすることは困難であり、この場合３ｄＢ帯域内の振幅特性が変調精度に効いてくる。

【００６７】（５）ロールオフ率が等しい場合、３ｄＢ

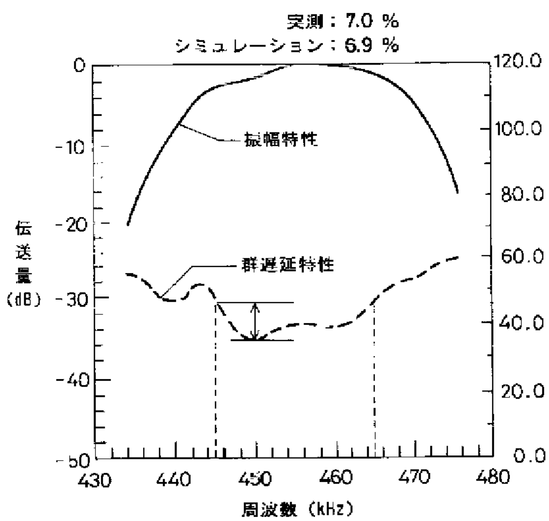
【図１】



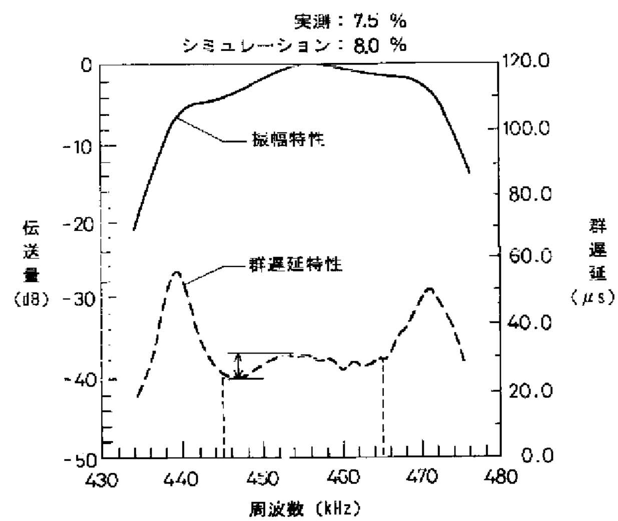
【図２】



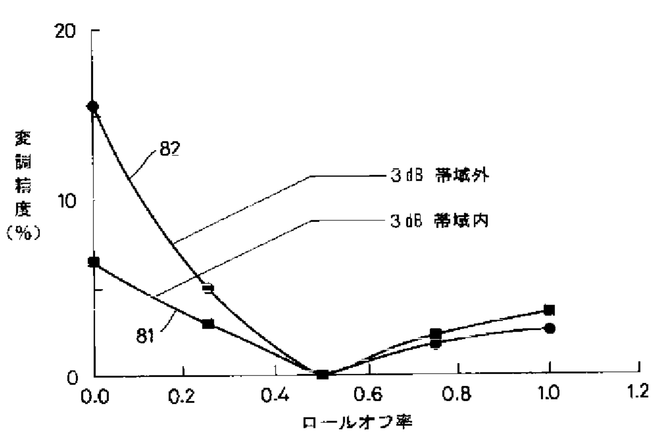
【図３】



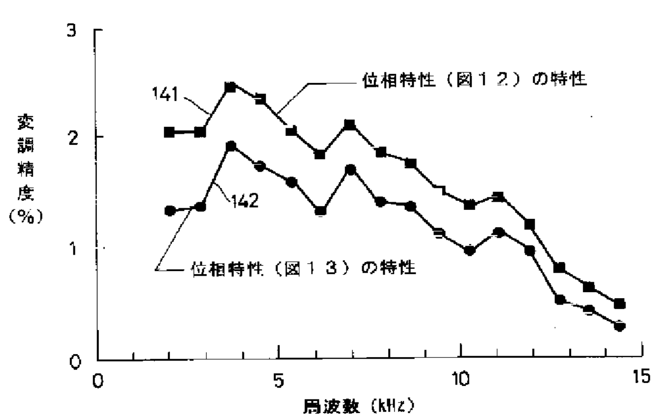
【図４】



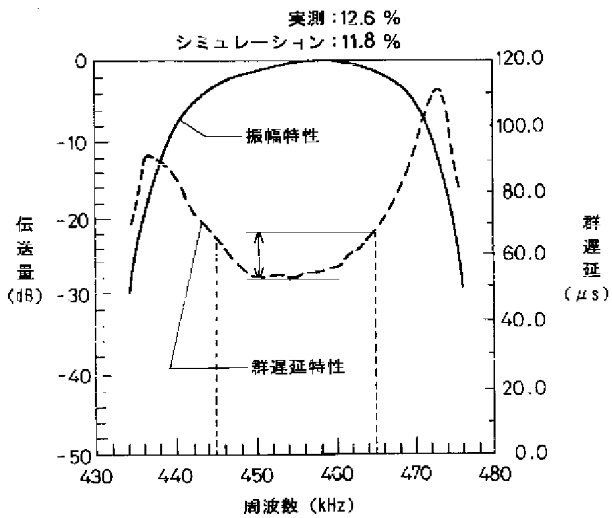
【図８】



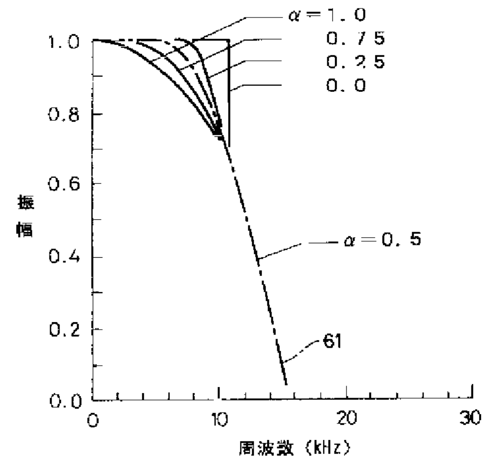
【図１４】



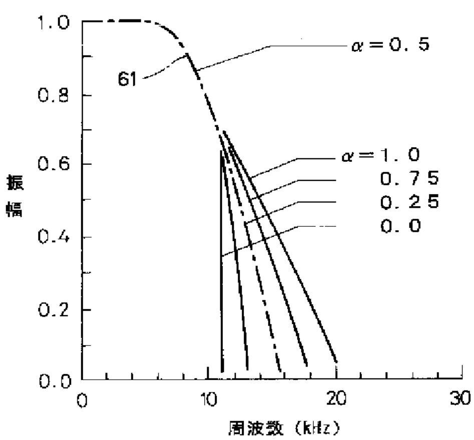
【図5】



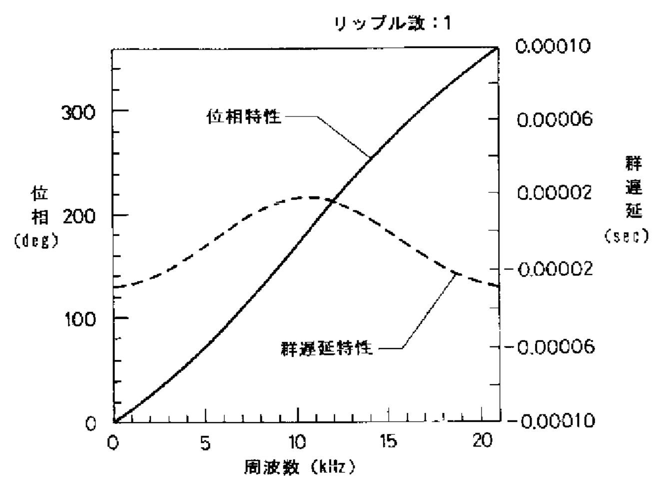
【図6】



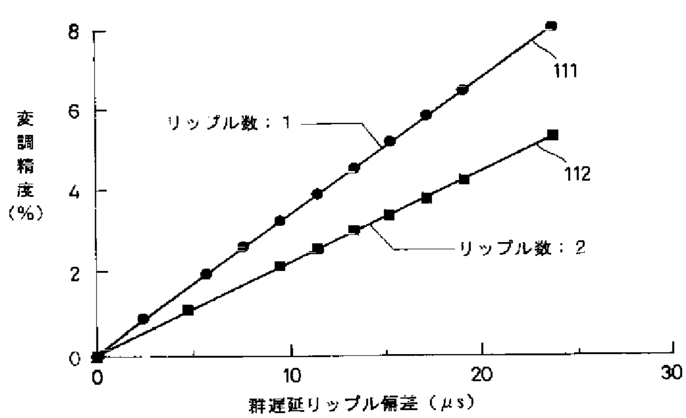
【図7】



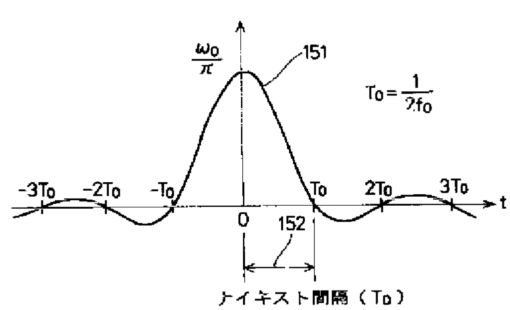
【図9】



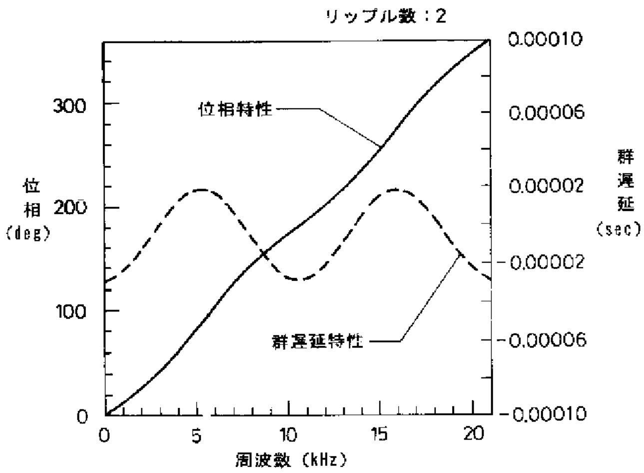
【図11】



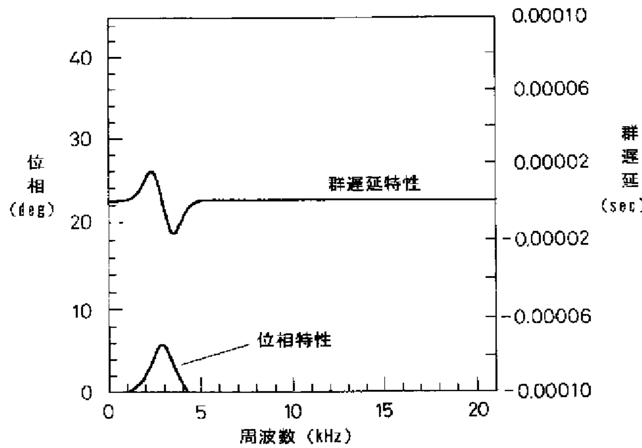
【図15】



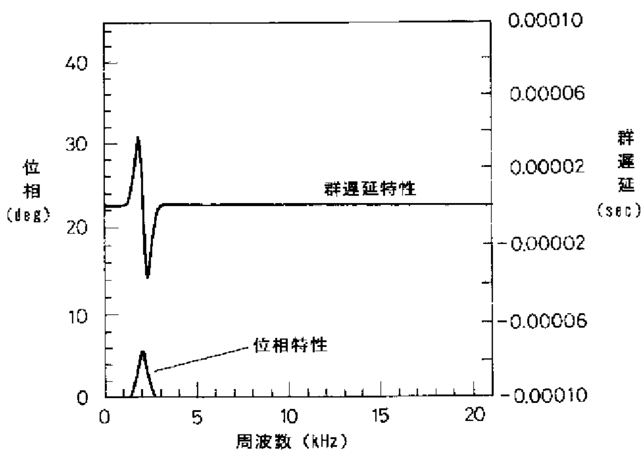
【図10】



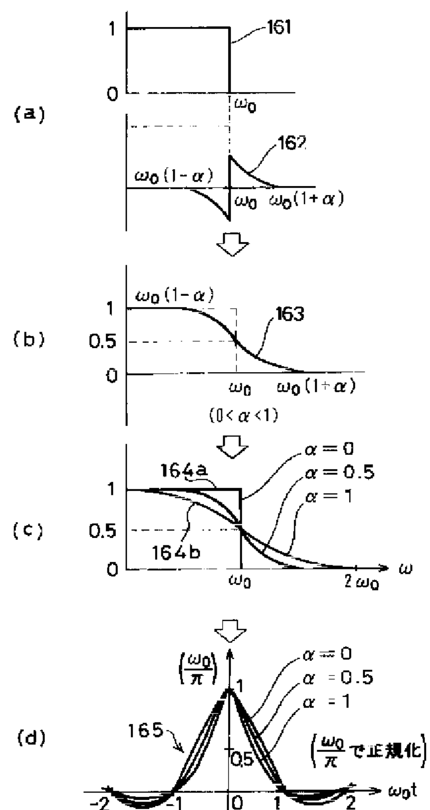
【図12】



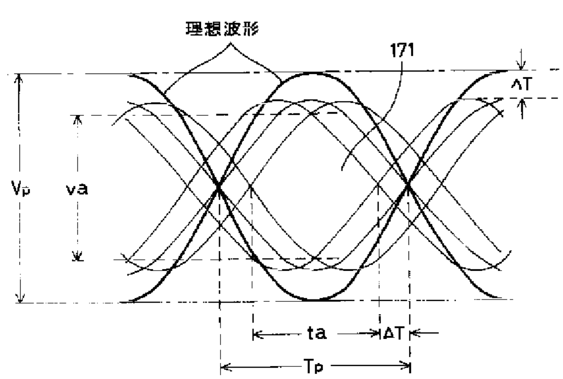
【図13】



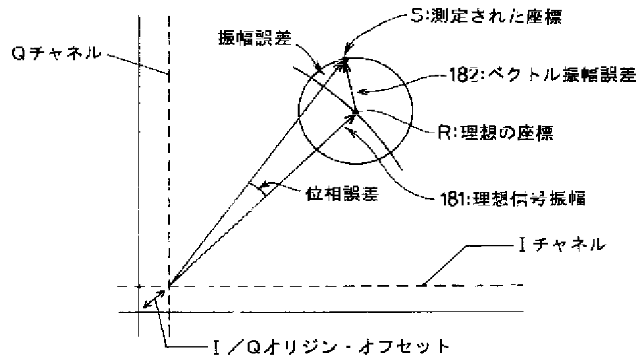
【図16】



【図17】



【図18】



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